

Cable Median Barrier Maintenance Manual

Texas Department of Transportation

Product 0-5609-P1

URL: https://tti.tamu.edu/documents/0-5609-P1.pdf

August 2008

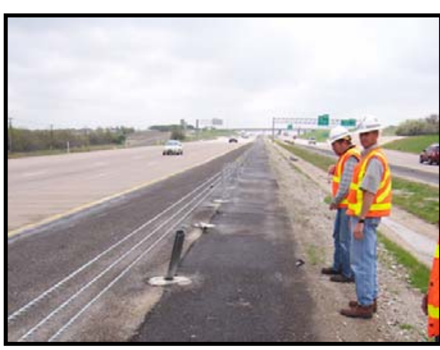


Table of Contents

Chapter 1

Introduction

Contents:

Chapter 1

Section 1

Background

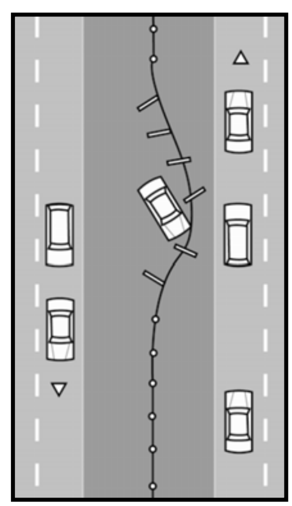
Cable Barrier Maintenance Manual

This *Cable Barrier Maintenance Manual* was developed as part of the 0-5609 *In-Service Evaluation of Cable Median Barrier Performance* research project. The intended audience for the manual is TxDOT maintenance personnel responsible for the repair and general maintenance of cable barrier systems installed in their section. The manual provides maintenance personnel with general guidance regarding the maintenance and repair of cable barrier systems based on information collected in state and national surveys. Text boxes labeled with the "Guidance" term highlight important recommendations. High-tension cable barrier systems are produced by approved manufacturers and each have unique designs and maintenance needs. For barrier-specific maintenance and repair procedures, TxDOT maintenance personnel should use the manufacturer's manuals.

Guidance – For barrier-specific maintenance and repair procedures, TxDOT maintenance personnel should use the manufacturer's manuals.

Overview of Cable Barrier Systems

Cable barrier is a barrier that is best used in relatively wide and flat medians to assist in preventing cross-over collisions by capturing and redirecting out-of-control vehicles that would otherwise cross into the opposite side of the road. Cable barrier differs from concrete and metal-beam median barriers in that it can be installed on sloped terrain (1V:6H) and still perform effectively. Though the cable barrier requires a lot of lateral space for deflection, it is a more "forgiving" system when struck by an out-of-control motorist because it is designed to reduce impact forces to the vehicle occupants.



General Maintenance Considerations

Cable barrier systems must be maintained for best performance. This maintenance is not limited to repair after impacts but also to sometimes checking heights and proper tension in the cables. Annual and semi-annual checks are necessary because of the cable system can lose tension over time due to stretching and/or settlement of movement of the system anchors. One recent study evaluated the loss of tension in cable barrier systems. This study tried to determine if using the pre-stretched cables would eliminate the need to re-tension the cables; however, it was concluded that pre-stretching the cable does not solve the problem and regular re-tensioning is required.

Guidance - Cable barrier systems must be maintained for best performance — it is very important to make sure that cables are at the specified height and tension of the barrier manufacturer.

For *pre-stretched* cables, the cable tension should be checked at least *once* per year.

For *standard* cable, the cable tension should be check at least *twice* per year.

Damage to a cable barrier system during impact is usually limited to support posts and connections. All damaged components should be replaced. Impacts near anchors can sometimes damage the field applied end fittings. If damage is found, replacement is required. Cables should be inspected for local damage. Damage to the cables rarely occurs; however, local kinks, bird caging (unseating of cables and strands in a short section), or severing of any wires in the cable dictates the need to replace the damaged section. If a section of cable is to be replaced, the repair personnel should consider the addition of a turnbuckle at the damaged location to help with re-tensioning of the system.

Impacts will often require re-tensioning of the system. At a minimum, tension should always be checked after impacts.

Maintenance issues for cable barrier systems might be the most overlooked because of the overwhelming desire to install as much barrier as possible to prevent cross-median crashes. Many sources have found that cable barrier systems are anywhere from 25 to 33 percent the cost per mile for installation as compared to concrete median barriers. However, ongoing maintenance costs for cable barrier systems are substantially higher than compared to concrete barriers. The earliest cable barrier system was installed in 2003 so there still is not a great deal of experience with long-term maintenance and repair costs.

Guidance - TxDOT should continue to monitor the long-term maintenance costs for cable barrier systems to better understand life-cycle costs compared with other traditional barrier systems such as concrete median barriers.

TxDOT Approved Cable Barriers

TxDOT uses four suppliers for the high-tensioned cable median barrier systems installed across the state: Trinity, Gibraltar, Nucor (Marion Steel), and Brifen. Each of the four proprietary systems has a unique post design, cable placement, and end treatment. All these cable barrier system's posts are being placed in concrete drill shafts with sockets for ease of repair and maintenance. Most districts are also placing mow strips with the cable barrier systems for maintenance considerations.

The evolution of cable barrier systems in Texas began with the installation of a one-mile experimental section of Brifen system on Interstate 820 just west of Interstate 35W in the Fort Worth District. The use of cable median barrier systems has increased rapidly since the experimental section, aided largely by the availability of safety bond money approved by voters in 2003 as part of Proposition 14. The safety bond money will allow TxDOT to install over 700 miles of cable median barriers throughout the state.

Trinity
Cable Safety System

Gibraltar
Cable System

NUCOR
Hi-Tension Cable

Brifen
Wire Rope Safety Fence

Section 2

Manual Organization

Organization of the Cable Barrier Maintenance Manual

The *Cable Barrier Maintenance Manual* contains the following chapters:

- Chapter 2, Barrier Installation: Provides basic information on the installation of cable barrier systems and inspection procedures.
- Chapter 3, Barrier Repair and Maintenance: Includes guidance on the repair and maintenance of cable barrier systems.

The Appendix of the *Cable Barrier Maintenance Manual* includes several standard forms that districts can use to standardize maintenance operations for cable barrier systems.

Chapter 2

Barrier Installation

Contents:

Chapter 2

Section 1

Installation Guidance

Barrier Placement

The placement of cable median barrier is probably more difficult than most roadside hardware. Unlike typical strong-post guardrails, cable median barriers are sometimes located farther away from the edge of the travel lanes. Strong-post guardrails are most often installed at the edge of the shoulder so the approach slope is generally nearly flat and the surface is generally paved or a well compacted base material. Cable median barriers, on the other hand, may be at the edge of the shoulder, in the center of the median in the middle of the drainage feature, or somewhere on the grassy slope of a depressed median. Cable median barriers may be more prone to performance problems because they are often positioned farther from the traveled way and on slopes. Vehicle travel paths will be affected by the slope. There is more opportunity for vehicles to strike the barrier at difficult impact conditions involving non-tracking and out-of-position suspensions.

From the maintenance point of view, cable systems are effective but intensive to maintain. However, the majority of maintenance staff believes the reduction in cross-median fatalities is worth the increased workload compared to other types of barriers. Surveys of personnel that maintain cable barrier systems revealed that there was a strong preference for mid-median versus shoulder installations, probably because repair activities occur farther from travel lanes which minimize exposure. This maintenance-related preference is somewhat contradictory to current design guidelines and also to existing practice, where the overwhelming majority of cable barrier has been placed along the shoulder. It is important for maintenance personnel to understand that cable barrier system placement is extremely important to performance and ultimately the ability to prevent vehicles from crossing into the opposing traffic lanes.

Installation Special Specification

TxDOT has developed a series of special specifications to assist engineers and field personnel in the deployment of cable barrier systems on state roadways. The following reference table provides a history of these three statewide special specifications for cable barrier systems.

Special Specification Number	Title	Date Issued	Link for Specification Memorandum
5084 (04)	Cable Barrier System	March 11, 2005	ftp://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/chngmemo/de-23-06.pdf
5278 (04)	Cable Barrier System	January 2, 2006	ftp://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/chngmemo/de-01-06.pdf
5367 (04)	Cable Barrier System	July 28, 2006	ftp://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/chngmemo/de-30-06.pdf

Temperature Effects

Maintenance personnel should understand that large temperature changes will cause large variations in cable tensions. If a high-tension cable barrier system is installed at the peak of summer heat, the installed tension may be as low as 2,500 lb. In sub-freezing temperatures of the following winter, the rope tensions may exceed 7,500 lb. Therefore, problems with anchorage or slippage may not be evident for extended periods. Additionally, many of the high-tension systems have been tested at or near 5,000 lb tension and deflections will vary with variations in tension caused by temperature variations. All four cable barrier system manufacturers provide charts with wire rope tensions based on a range of temperatures from as low as -10° and as high as 110° Fahrenheit.

CABLE TENSION CHART	
F	lbf
-10	8951.2
0	8534.8
10	8118.4
20	7702.0
30	7285.6
40	6869.2
50	6452.8
60	6036.4
70	5620.0
80	5203.6
90	4787.2
100	4370.8
110	3954.4

NUCOR/SAFERoads U.S. High Tension Cable System TL-3 Tension Chart
(TxDOT Standard Drawing: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/htcstl3.pdf)

CABLE TENSION CHART		
F	Std. Cable	Pre-Streched
-10	8600	7300
0	8200	7000
10	7800	6600
20	7400	7300
30	7000	6000
40	6600	5600
50	6200	5300
60	5800	5000
70	5600	4800
80	5000	4300
90	4600	4000
100	4200	3600
110	3800	3300

Allowable Deviation from Chart:
200 lbs/force.

Trinity CASS TL-3 Tension Chart
(TxDOT Standard Drawing: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/casstl3.pdf)

CABLE TENSION CHART		
F	Std. Cable	Pre-Stretched
-10	8600	7300
0	8200	7000
10	7800	6600
20	7400	6300
30	7000	6000
40	6600	5600
50	6200	5300
60	5800	5000
70	5600	4800
80	5200	4300
90	4800	4000
100	4400	3600
110	4000	3300

Allowable Deviation from Chart:
200 lbs/force.

Trinity CASS TL-4 Tension Chart
(TxDOT Standard Drawing: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/casstl4.pdf)

TENSION CHART	
AMBIENT TEMPERATURE	ROPE TENSION
F	LBS
100	2110
95	2531
86	3150
77	3769
68	4387
59	5006
50	5625
41	6244
32	6863
23	7481
14	8100
0	9100

Brifen WRSF TL-3 Tension Chart
(TxDOT Standard Drawing: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/wrsftl3.pdf)

CABLE TENSION CHART	
F	Std. Cable
-10	8000
0	7600
10	7200
20	6800
30	6400
40	6000
50	5600
60	5200
70	4800
80	4400
90	4000
100	3600
110	3200

Allowable Deviation from Chart: ± 10%

Gibraltar TL-3 Tension Chart
(TxDOT Standard Drawing: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/gcbstl3.pdf)

CABLE TENSION CHART	
F	Std. Cable
-10	8800
0	8400
10	8000
20	7600
30	7200
40	6800
50	6400
60	6000
70	5600
80	5200
90	4800
100	4400
110	4000

Allowable Deviation from Chart:
200 lbs/force.

Gibraltar TL-4 Tension Chart
(TxDOT Standard Drawing: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/gcbstl4.pdf)

Socketed Posts

Current TxDOT guidance stipulates that all cable barrier systems should be placed in concrete drill shafts with sockets for ease of repair and maintenance. Damaged posts are removed from the sockets; new ones are inserted and the cables are reattached or placed in the posts. The sockets consist of a metal sleeve embedded in a 30 inch to 36 inch deep by 12 inch diameter small concrete foundation. Most sockets have a top reinforcing ring and the vertical reinforcement varies by manufacturer. Most sockets are cast in place; however some have been pre-cast. Some states have experienced displacement or breakage of the socket foundations in poor soil conditions. Additional reinforcement and/or increased foundation depth should be considered when poor soil conditions are known to exist. In Texas, 75 percent of maintenance sections have reported cracking, spalling, and break-offs in the concrete sockets.

Mow Strips

Many states, including Texas, are trying to address the difficulties associated with removing grass or other vegetation that grows under cable barrier systems. A common solution employed throughout the United States is a mow strip, a narrow piece of pavement or other material placed directly beneath the barrier to prevent the growth of vegetation and facilitate mowing. For future maintenance considerations, the TxDOT Maintenance Division encourages the use of mow strips to reduce future hand mowing or herbicide operations due to cable barrier system installation. Several different mow strip designs (concrete, asphalt and rip rap) have successfully been implemented on TxDOT projects with typical installation cost per mile ranging from $45,000 to $55,000 for concrete and $75,000 to $90,000 for asphalt.

Cable Heights

Another key consideration with installation of cable barrier systems is cable height. The height of the cables above the ground is very important to the proper function of the barrier. It needs to be carefully maintained during the initial installation and must be monitored during maintenance that is performed, particularly following an impact.

From a design and construction standpoint, correct cable height along outside shoulders is usually easy to establish due to the constant slope of the shoulders. Correct cable height can be more easily established in median installations by running the cable barrier system a set distance from the shoulder line of one side of the highway, rather than down the center of the median. By putting the cable in an area where the slope does not vary up and down in short distances, it is easier to maintain a uniform height for the cables above the surface thus preventing high or low areas where the barrier can be more easily under- or over-driven.

It is important to maintain the cables at the correct heights set by the locating pegs on the sides of the posts. Some districts in the north may have issues created by winter weather conditions based on experiences of cold-weather states. In areas where heavy snow is thrown over and through the cable system, the impact of snow and ice on cables and posts may be strong enough to break or pop out the locator pegs, allowing the cables to sag below the design height. It may be necessary to replace the pegs and reposition the cables to the proper height periodically.

It is very important that the cable height at both sides of the impact point be checked whenever crash damage is being repaired. Movement of the cables during impact often causes the locater pegs to break or pop out of their holes for some distance from the point of impact, even on posts that have not been bent. Cables that are too low or too high are better than no barrier at all. However, penetration data from in-service evaluations of cable barrier systems has demonstrated that their effectiveness is reduced. Several TxDOT maintenance sections have developed tools based on the recommended manufacturer cable heights that can be used to quickly check cable heights.

Guidance – Cable heights should be checked during installation and following impacts to make sure they are within manufacturer's specifications.

Soil Considerations

Maintenance personnel should be aware that the soil where cable barrier systems are installed can have a significant effect on barrier performance, particularly with the terminal anchor sections. A number of states and TxDOT maintenance sections have experienced movement of anchor footings (foundations) in a few of the different cable barrier systems. High plasticity and/or highly saturated soils have typically been the problem areas. From a maintenance standpoint, this is a problem that is probably best addressed during the project design phase so that proper anchor footings can be engineered to increase the performance of the cable barrier system over its life. If soil properties are determined before the placement of the system, the generic anchor footing can be checked to see if the design is acceptable for the expected loading (i.e., sustained static tension load during cold weather and dynamic conditions caused by impacts). For legacy systems, maintenance personnel should routinely inspect terminal anchors to see if there has been any movement that could potentially affect the barrier performance.

Guidance – Soil conditions are best addressed during the design stage; however, maintenance personnel should routinely inspect terminal anchors for movement that could affect cable barrier performance.

Training

Training of TxDOT maintenance personnel is an essential element to the success of maintaining and repairing cable barrier systems; however, to date no formal training requirements have been adopted. Training has occurred in a variety of forms including: on-the-job, manufacturer representatives, video, contractors, and none. Several states, notably Arizona, have formalized the requirement for training on installation and maintenance of cable barrier systems. The following sections outline a training program for TxDOT.

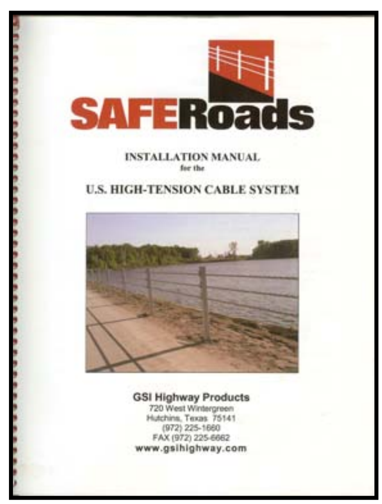
Installation Training Module

The installation contractor shall sponsor and arrange for two manufacturer-supported training sessions, the first during cable barrier installation and the second before cable-barrier acceptance. Course content and materials (handouts and trainer's reference works) should be certified by the manufacturer as appropriate for their system. The certification letter should be presented to the project engineer a minimum of two weeks prior to the training session. An electronic version of the course materials should be provided to the area engineer, in a PDF format, on the day of the training.

The proposed date of the installation training shall be submitted to the area engineer for review and approval a minimum of 30 calendar days prior to the training session date. The training shall have the following participants:

- prime contractor's field superintendent or designated representative(s),
- cable barrier sub-contractor's field supervisor or designated representative(s),
- area engineer, or designated representative(s), and
- construction inspector(s).

The training should be limited to twelve participants selected by the area engineer; the area engineer shall have final approval of participants. Every participant shall be provided with a complete set of course handouts, the manufacturer's installation manual, and the manufacturer's plans for the approved system. The training course and accompanying course material should cover, at a minimum, the following subjects:



- description and function of the system components;
- sequence of construction operations;
- manufacturer's requirements for installing end-anchors and post foundations, including, but not limited to sizes, reinforcement, concrete design strength, curing

time, concrete testing, and locations;

- terminal assembly installation;
- cable barrier system installation;
- cable tensioning;
- discussion of critical tasks;
- inspection; and
- group quiz and review of answers.

Maintenance Training Module

The maintenance training should be held a minimum of two days prior to acceptance of the system; the proposed date should be submitted to the area engineer a minimum of 30 calendar days prior to the training session date for review and approval. The training should have the following participants:

- district director of maintenance or designated representative(s),
- maintenance section supervisor or designated representative(s),
- maintenance section personnel, and
- maintenance contractor personnel.

The training should be limited to twenty participants selected by the area engineer; the area engineer should have final approval of participants. Every participant should be provided with a complete set of course handouts, the manufacturer's maintenance manual, and the manufacturer's plans for the approved system. The training course and accompanying course material should cover, at a minimum, the following subjects:

- description of the system components,
- discussion of critical features,
- inspection:
  - median cable barrier,
  - terminal assembly,
- median cable barrier component replacement,
- terminal assembly replacement,
- cable tension monitoring and re-tensioning,
- freeing captured vehicles,
- field splicing of cable, and
- group quiz and review of answers.

Chapter 3

Barrier Repair and Maintenance

Contents:

Chapter 3

Section 1

Typical Repair Statistics

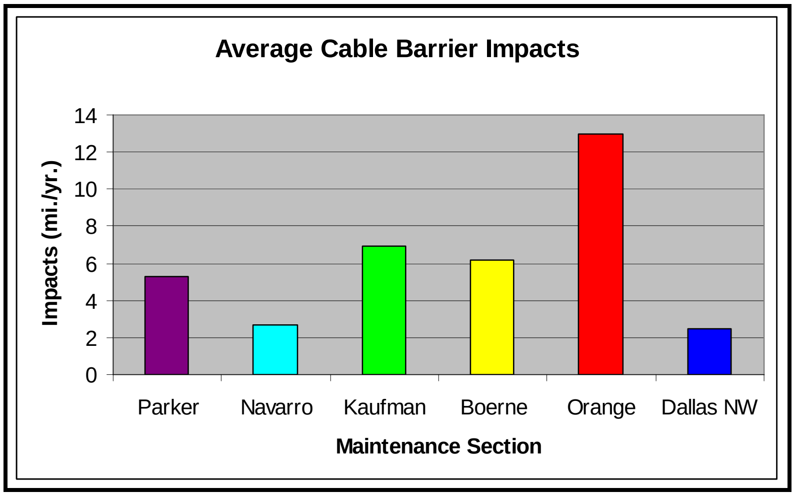
The installation of any roadside safety device, particularly longitudinal systems like cable median barriers, is likely to increase the frequency of collisions. Many impacts to cable barrier systems could also be classified as saves – from cross-median collisions that would likely result in multiple injuries and/or fatalities. There have been thousands of impacts of cable barrier systems in Texas and many lives have been saved. The South Carolina Department of Transportation recently had a press event in October 2006 to announce that its cable median barrier program has recorded more than 10,000 impacts since the program began in 2001. The information presented in this section provides some typical cable barrier repair statistics, including topics such as:

- barrier impacts,
- repair time,
- repair personnel, and
- repair costs.

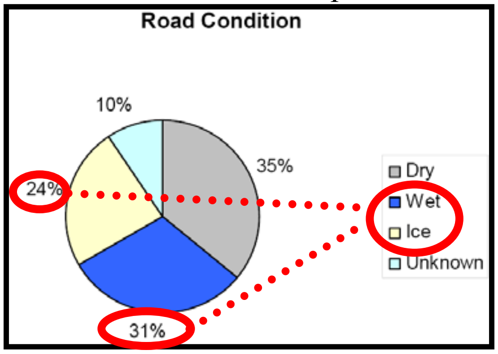
Barrier Impact Statistics

Frequency. The frequency of impacts to cable barrier systems is dependent on many factors, most notably traffic volume level (average daily traffic) and barrier placement (relative distance from travel lanes). Hi-tension cable barrier is still a relatively new technology in the United States; however, several states have gathered significant data on cable barrier performance – including the frequency of impacts. Research on locations in Texas has revealed that a good rule of thumb for planning and budgeting purposes is to expect an average of 7 impacts per mile per year (mi/yr) on a section of cable barrier system. Impact averages ranged from a low of 2.7/mi/yr (Dallas District - Navarro County maintenance section) to a high of 13.0/mi/yr (Beaumont District - Orange maintenance section). This average of 7 impacts per mile per year is similar to values in other states such as Ohio (7.6), which performed a detailed three-year in-service evaluation of their high-tension cable barrier systems.

<u>Guidance</u> - Expect an average of *7 impacts per mile per year* on a section of cable barrier system.

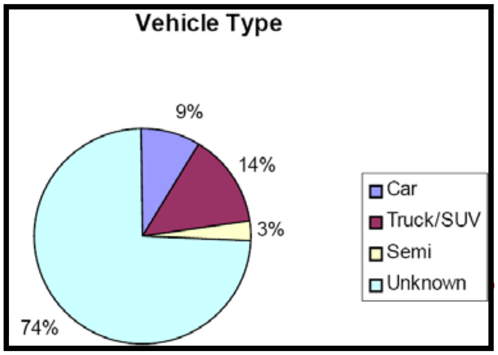


Road Condition. Analysis of cable barrier impact data has revealed that impacts are much more likely to occur when roadway conditions are slick (i.e., rain, ice, or snow). Maintenance and repair activities may increase during the seasons of the year where these road conditions are more prevalent. Data from the Weatherford maintenance section supports this assertion, finding that over half (55 percent) of impacts occur when the roadway is wet or icy.



<u>Guidance</u> - Expect maintenance and repair activities to increase during cold and rainy seasons of the year.

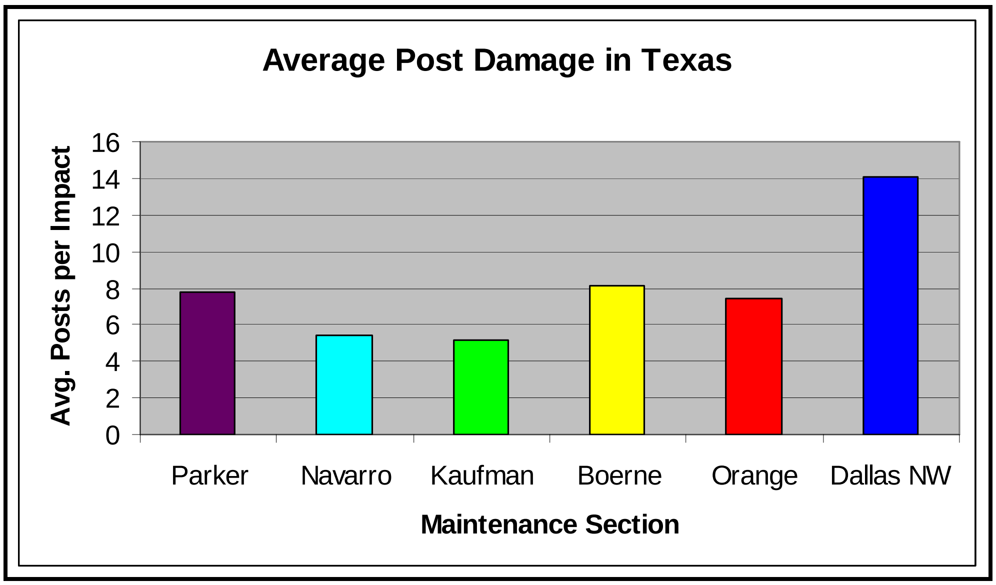
Availability of Crash Reports. Because cable barriers are designed to catch vehicles and minimize the forces put on the occupants, motorists are often able to drive away from the incident scene. Previous studies of cable barrier impacts in other states have shown that 54 percent do not have a police crash report associated with them. This national statistic is validated by Texas experience, with the Weatherford maintenance section finding that in



almost three out of every four cable barrier impacts the vehicle type is unknown. This state statistic means the maintenance personnel will have to rely on other techniques (drive alongs, motorist reports, etc.) to identify that the cable barrier system has been damaged.

> **Guidance -** Most cable barrier impacts will not be documented by police crash reports so maintenance personnel will need to rely on other techniques to identify cable barrier system damage.

Damaged Posts. The number of posts that need to be replaced in a cable barrier impact is a good indicator of damage level and correlates strongly to the amount of repair time that will be necessary. Several states have collected data on the average number of damaged posts per impact, with Ohio reporting an average of 5.7 and Washington an average of 6.5. Analysis of Texas cable maintenance data has shown that an average of 7.3 posts are damaged, with a low average of 5.2 in a rural location and a high average of 14.1 in an urban location.



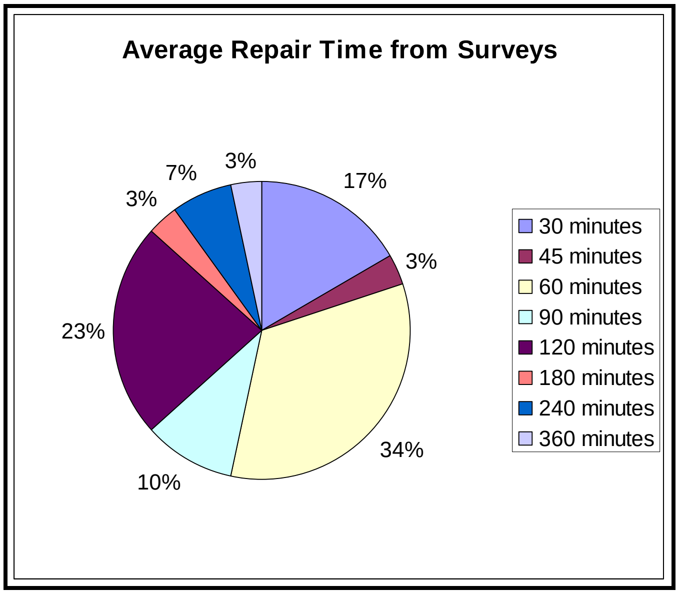
> **Guidance -** Expect an average replacement rate of *7 posts per impact* on a section of cable barrier system.

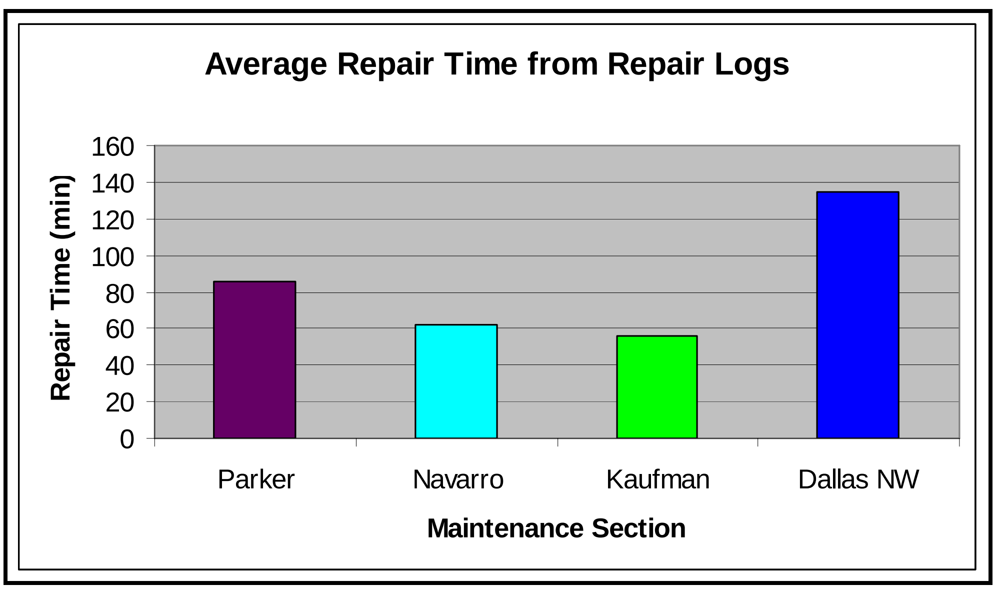
Repair Time Statistics

The amount of time spent on repairing damaged cable barrier systems is an important element to track and evaluate. Cable barrier system manufacturers market the ease of repair and maintenance of their products. Two sources of data were collected to assess the average repair time for cable barrier systems in Texas:

- cable barrier maintenance survey and
- data from repair logs from four maintenance sections.

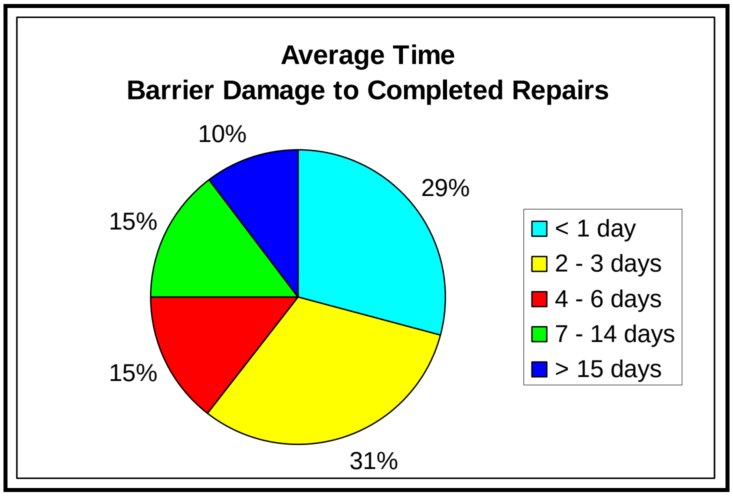
The thirty responses from the cable barrier survey estimated that 100 minutes were spent on site for an average level or repair. Similarly, the data from repair logs in the Dallas Northwest, Kaufman County, Navarro County, and Parker County maintenance sections showed that 85 minutes were spent on site for an average repair.





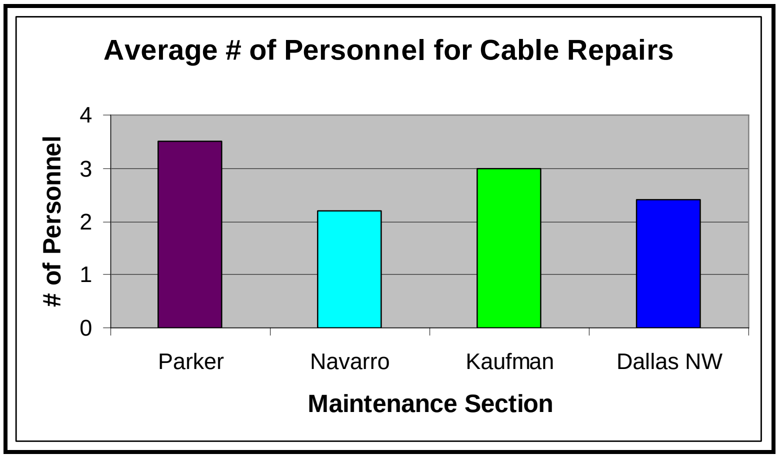
Guidance - Expect to spend about *90 minutes* on-site for an average cable barrier repair.

Several states have also evaluated the amount of time that elapsed between when the cable barrier system was damaged and when repairs were completed. The elapsed time ranged from 4–6 days in Ohio and 2–14 days in Washington. One TxDOT maintenance section provided sufficient data to assess the amount of time that elapsed between when the cable barrier system was damaged and when the repairs were completed. The average elapsed time was approximately 5 days, with a high value of 26 days. It should be emphasized that 60 percent of the repairs were completed in less than a 3 day timeframe.



Repair Personnel Statistics

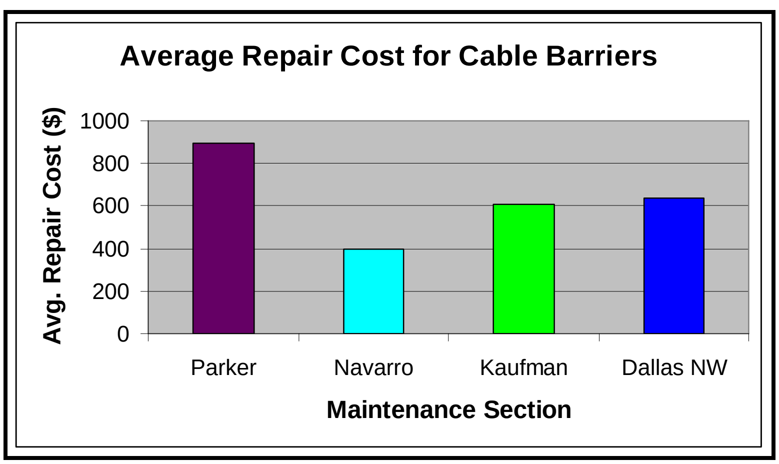
The amount of personnel needed to repair damaged cable barrier systems is another important element to track and evaluate. Cable barrier system manufacturers also publicize that many maintenance and repair activities can be accomplished with one employee. Data from several maintenance sections were collected to assess the average number of repair personnel needed for cable barrier systems in Texas. The average number of personnel needed for repairs ranged from a low of 2.2 to a high of 3.5, with an average of approximately 2.8.



<u>Guidance</u> - Expect to use *2 to 3 employees* for the typical cable barrier repair.

Repair Cost Statistics

Limited funding and resources for maintenance activities make it important to adequately gauge the costs of repairs for cable barrier systems. Data from several TxDOT maintenance sections revealed that average costs ranged from $400 to $900 dollars per repair, including labor, equipment, and materials. The average repair cost for cable barriers based on Texas data was $635. National data fall into this range and are close to the Texas average with Ohio reporting an average repair cost of $631 and Washington reporting $800.



<u>Guidance</u> - Expect an average cost of cable barrier repair to be approximately ***$635***.

Section 2

Contract vs. State Forces

Contracting Approaches

There are basically two approaches that can be used to maintain and repair cable barrier systems: contracted maintenance versus the traditional method of in-house TxDOT forces. To date, most districts have chosen to utilize TxDOT personnel to maintain and repair cable barrier systems; however, some districts and even individual maintenance sections have utilized contracted maintenance personnel for this task.

State Forces

The use of state personnel to maintain and repair cable barrier systems requires dedication of time and resources. Some maintenance sections that have a high number of miles of barrier and also multiple barrier systems installed have still chosen to keep maintenance and repair activities in house. With frequent impacts and repair needs, some maintenance sections have determined that they do not have the manpower and chosen to use their personnel for other maintenance needs.

Contract Forces

The use of private companies for maintenance activities on state roadways is a common practice in Texas for many activities such as mowing and litter control. Maintenance and repair of cable barrier systems by contract has been expanded in recent years as the number of installed miles in Texas has rapidly increased. Several jurisdictions have chosen to fully utilize contractors to maintain their cable barrier systems.

The South Carolina Department of Transportation, which has almost 500 miles of installed cable barrier on Interstate facilities, recently approved a statewide cable barrier maintenance contract for $2 million per year in FY2008/2009. The repair of the interstate cable median barrier system is performed under contract in order to return the damaged section of cable to service as soon as possible. The contractor has 96 hours to complete repairs once notified thus providing a high level of service for this important roadside device.

Some districts have chosen to include cable barrier maintenance activities as a subsidiary item in their metal beam guard fence (MBGF) maintenance contracts. A recent effort within TxDOT to use contract forces for maintenance and repair specifically for cable barrier systems is in the Bryan District's Walker County maintenance section. A one-year local-let maintenance contract for an estimated cost of $268,050 is being used to outsource repair of a 16 mile section of cable barrier. The decision to use contract forces versus state forces was made because the barrier gets hit frequently (weekly) and repair activities caused time scheduling issues. The Dallas District's Rockwall and Navarro County maintenance sections also utilize similar approaches with the exception of lengthening the contract service timeframe from one to two years.

Section 3

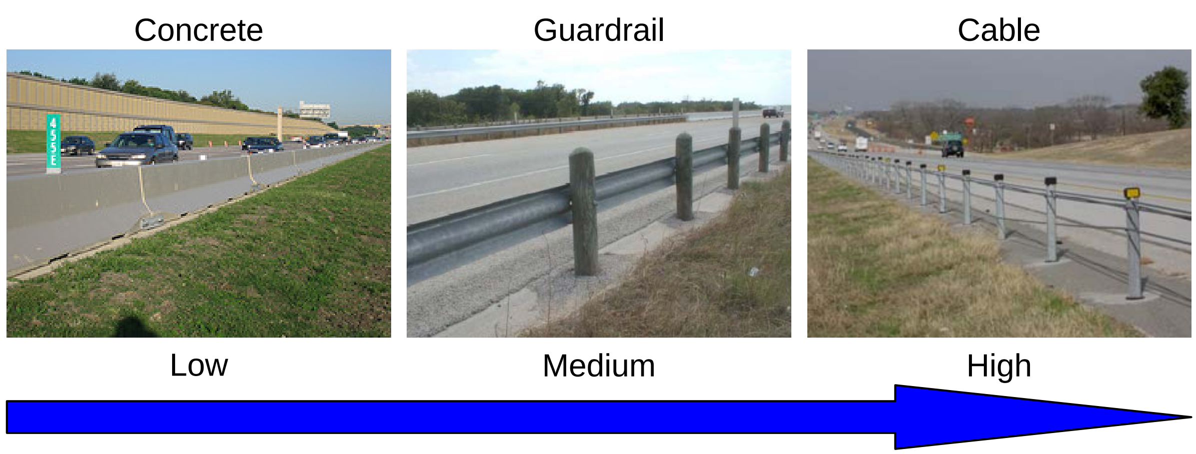
Cable Repair

Cable Repair vs. Other Barrier Repair

Typically, cable barrier repairs are quicker and less costly than repairs to guardrails or concrete barriers. However, guardrails and concrete barriers are less likely to require repair from minor collisions because they are more durable.

All types of barriers require regular maintenance. Cable barriers and guardrails require more intensive routine maintenance than concrete barriers. For example, crews must trim brush and weeds away from guardrails and cable barriers and must check cable barrier tension regularly.

Anytime maintenance workers are in a highway median they are exposed to nearby traffic increasing their risk of injury. Increasing the time they spend in the median increases their risk. In addition, TxDOT often needs to restrict or redirect traffic during maintenance work to help keep workers and drivers safe. This restriction can cause traffic delays, inconvenience to drivers, and increase the risk of collisions and time of day for repairs may be limited by restrictions in the major metropolitan areas.



General Barrier Maintenance Requirements

Guidance - Schedule cable barrier repair activities to minimize traffic delays and inconvenience to drivers with the safety of workers being the primary concern.

Maintenance Management Manual

The TxDOT *Maintenance Management Manual* provides some useful information for this *Cable Barrier Maintenance Guidebook*. The *Maintenance Management Manual* clearly defines the level of service for maintenance, with first priority going to highway components that provide for the safety of the traveling public. Cable barrier systems fall into the priority one category because they are an appurtenance installed to protect the public by preventing cross-median collisions. The desirable, acceptable, and tolerable levels of services are defined in the following table.

Component	Desirable Level	Acceptable Level	Tolerable Level
Safety Appurtenances Includes guardrail, crash attenuators, concrete median barriers, driveway culvert safety end treatment, etc.	Maintain all safety appurtenances to original design standards; all hardware functional; no noticeable appearance defects.	Maintain all safety appurtenances to original design standards; all hardware functional; few noticeable appearance defects.	Maintain all safety appurtenances to original design standards; all hardware functional; readily noticeable appearance defects.

TxDOT Maintenance Management Manual, Chapter 3, Section 2
ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/mmt.pdf)

Special Specifications

TxDOT has developed two sets of special specifications to guide the installation and repair of cable barrier systems. Chapter 2, Section 1 of this manual includes the set of special specifications that provide guidance on installation of cable barrier systems. The set of special specifications that provide direction on repair of cable barrier systems is shown in the reference table below:

Special Specification Number	Title	Date Issued	Link for Specification Memorandum
5279 (04)	Repair Cable Barrier System	January 2, 2006	ftp://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/chngmemo/de-02-06.pdf
7194 (04)	Repair Cable Barrier System	January 13, 2006	ftp://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/chngmemo/de-03-06.pdf
7224 (04)	Repair Cable Barrier System	May 12, 2006	ftp://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/chngmemo/de-23-06.pdf

Cable Downtime

The amount of time a cable median barrier system is down should be kept to a minimum, in order to maintain the design performance and ability to effectively capture out-of-control vehicles. Several states, notably North Carolina, have been forced to implement policies regarding cable barrier downtime and inspection due to highly-publicized incidents where unrepaired sections of barrier led to severe cross-median crashes. Cable downtime is also an important issue in Texas, as there have been numerous cases (> 75) of re-hit on a damaged section of cable barrier.

The current special specification for repairing cable barrier systems establishes that physical repair should begin within 72 hours of notification, unless otherwise noted on project plans. This timeframe is for contractors during the barrier installation process; however, this 72-hour requirement may also be appropriate for general maintenance and repair contingent on available resources.

> **Guidance -** The amount of time a cable barrier system is down should be kept to a minimum, with *physical repair beginning within 72 hours of notification*, unless there are special circumstances.

Following an impact where a section of the barrier system has been damaged, TxDOT or contract personnel should place appropriate traffic control devices (vertical panels, traffic cones, barrels, etc.) along the damaged section to mark it.

Maintenance/Repair Log

Maintenance sections should track repair activities on cable barrier systems in order to document how resources are being utilized. Tracking is also important for being able to adequately evaluate the performance of barrier systems and to make informed decisions on future installations. The Weatherford maintenance section of the TxDOT Fort Worth District developed a standardized maintenance/repair log for wire cable median barrier systems (see Appendix). This form collects key crash and repair information. The crash information collected on the maintenance/repair log includes:

- date,
- time,
- light condition,
- road condition,
- highway,
- approximate reference marker,
- direction of travel,
- vehicle type,
- property damage only,
- number of injuries,
- number of fatalities, and
- prevent crossover.

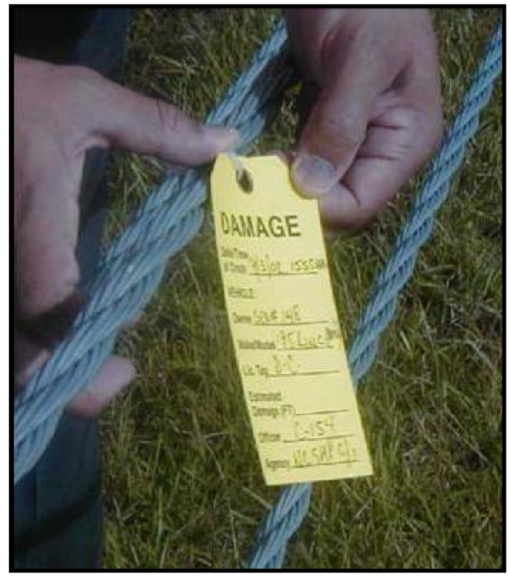
A brief description of the incident can also be provided in order to give further details about key topics (e.g., in case where a crossover was not prevented, the incident description could provide some reasons why). It should be understood that in many instances, crash information will not be available because a formal police investigation did not take place.

The repair information collected on the maintenance/repair log includes:

- date,
- time,
- product,
- number of posts replaced,
- end treatment involved,
- number of employees,
- repair time,
- material cost, and
- labor cost.

> **Guidance** - TxDOT maintenance sections should utilize the standard maintenance/repair log for cable median barrier systems to track and document activities.

Recovery of Maintenance Costs from System Impacts



The recovery of maintenance and repair costs from vehicle impacts is an area that requires more attention and development of formal policies. Currently, approximately half (53 percent) of TxDOT maintenance sections attempt to recover costs of barrier damage and/or repair costs from motorists who cause the damage. The cost recovery mechanism relies on the fact that a responsible party has been identified, most commonly in the form of a standard police crash report known as a ST-3. As has been previously reported, in many instances police reports are unavailable and a responsible party cannot be identified. Some states, notably North Carolina, have made attempts to formalize the identification of a responsible party and utilized the simple technique of damage claim tags to facilitate cost recovery by the department of transportation. The North Carolina program has been successful in recovering almost $956,000 from responsible parties caused by 1,592 impacts on cable barrier systems throughout their state.

TxDOT should initiate coordination activities with state (Department of Public Safety) and local law enforcement agencies regarding the need for increased collaboration and emphasis on the recovery of maintenance and repair costs from impacts to cable barrier systems throughout the state. Formal policies and agreements should be considered so that the cost recovery percentage for cable barriers is increased, thereby preserving funding for other maintenance priorities.

Guidance – Coordinate with law enforcement agencies so that a greater percentage of the actual maintenance and repair costs are recovered from responsible parties.

Section 4

Manufacturer Assistance

Manuals and Training

Since cable barrier systems are proprietary devices, TxDOT should rely on the product manufacturer's installation and repair manuals for specific guidance and direction regarding each of the four approved systems. The manufacturers are continuing to test and make modifications to these cable systems on an ongoing basis so product manuals are often updated. The training section included in Chapter 2, Section 1 of this manual provides specific information regarding information and materials that should be provided by the cable manufacturers to assist TxDOT personnel.

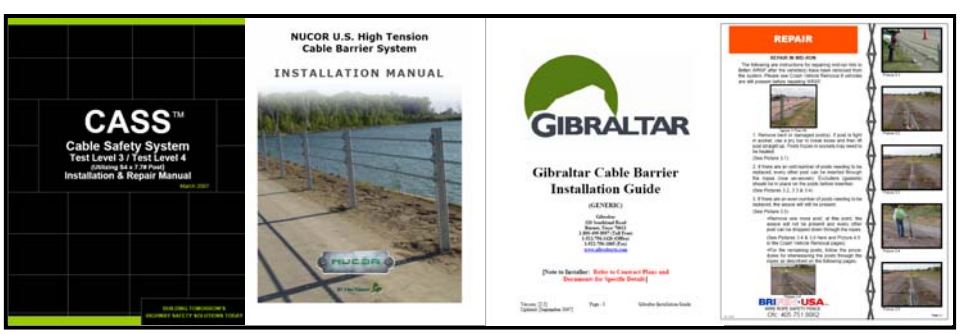
> **Guidance** - TxDOT should rely on product manufacturer's installation and repair manuals for specific guidance and direction regarding each of approved cable barrier systems.

Information regarding the manufacturer's product manuals is provided in the table below:

Manufacturer	Product	Website	Manuals
Trinity Industries	Cable Safety System	http://highwayguardrail.com/	Installation & Repair – March 2007*
Gibraltar	Cable Barrier System	http://gibraltartx.com/	Installation & Maintenance Guide – September 2007*
Nucor (Marion Steel)	U.S. High-Tension System	http://www.hightensioncable.com/	Installation Manual – October 2006*
Brifen	Wire Rope Safety Fence	http://brifenusa.com/	Repair – December 2007

* These manuals are available to download online.

In addition to manuals, several manufacturers also provide instructional videos or photo slideshows on cable barrier maintenance and common repair activities.



Section 5

Standard Tools

Repair of high-tension cable barrier systems is generally achieved with minimal manpower and equipment. Presently, all the high tension cable barrier systems are proprietary. While all use the same type of cable/wire rope, each use a different post design, different mounting hardware, and different cable mounting heights and spacing. Therefore, the posts and hardware used in one system are not interchangeable with posts and hardware used in other systems. There are some non-standard tools (e.g., Brifen Rope Spreader Tool) that are needed to facilitate cable barrier maintenance and repair. Fortunately, there are standard tools that maintenance sections should have that are useful in the maintenance and repair of all cable barrier systems.

Tension Meters

Tension meters are a standard tool that all TxDOT maintenance sections should have in order to accurately measure tension values in their cable barrier systems. Section 6 of this chapter provides more detailed information on cable tensioning. Some maintenance sections have experienced different tension readings (up to 500 pounds per square inch) based on the use of two different meters. Some states require that contractors use meters that are calibrated based on National Institute of Standards and Testing (NIST).

Post Drivers

Post drivers are another common tool that is utilized during cable barrier maintenance. Since cable barriers are a weak post system, they are designed to bend and dissipate forces during an impact. In many cases maintenance personnel can use replacement posts to raise and lower cables and remove damaged posts. In some cases posts are sufficiently damaged and disengaged from the cables where other tools and techniques are necessary to accomplish their removal.

Traffic Control

Maintenance personnel should follow all standard traffic control procedures during routine maintenance and repair activities. If possible, maintenance activities should be scheduled when impacts to traffic can be minimized. This scheduling will also benefit maintenance personnel by reducing their exposure and potential for injury.

Section 6

Cable Tensioning

Wire rope systems rely on tension of the ropes to redirect errant vehicles. If system tension is not maintained, deflections will increase and performance may be degraded. Tension may be lost due to:

- construction stretch,
- anchor movement,
- fitting slippage, and/or
- previous impacts.

Tension in the wire ropes is also affected by temperature changes. Most manufacturers of high tension systems provide tensioning charts based on temperature. Previous charts were based on ambient temperatures but rope temperatures can vary significantly (30-50 degrees Fahrenheit) from ambient temperatures. Therefore, tensioning of the system should be based on rope temperature, not ambient temperature. If field applied fittings have been used, it is good practice to mark ropes at fittings and monitor movement in fittings for possible slippage.

After Impacts

Impacts will often require re-tensioning of the system. At a minimum, tension should always be checked after impacts. Based on surveys of TxDOT maintenance supervisors, cable tension is commonly checked by field personnel after performing repairs. This check is a good practice and should be routinely done in accordance with manufacturer recommendations to keep the barrier performing as designed. Impacts or damage to cable anchor/terminal sections can also cause sections of the system to lose tension and allow the cables to sag as depicted in the picture to the right.

> **<u>Guidance</u> –** Tension in the cable should always be checked following repairs in accordance with manufacturer recommendations.

Annual Program

Routine checking of tension should also be performed, even in the absence of barrier impacts, in order to monitor performance over time. This is particularly important during the first few years following cable installation. Some maintenance forces utilize tension logs to document readings taken on their barrier systems.

> **Guidance** - Even in the absence of impacts, cable tension should be checked as part of the annual maintenance program.
>
> For *pre-stretched* cables, the cable tension should be checked at least *once* per year.
>
> For *standard* cable, the cable tension should be check at least *twice* per year.

Section 7

Parts Inventory and Storage

This section is written to assist maintenance personnel with techniques for inventory and storage of parts for repair of cable barrier systems. At this time the significant majority (85 percent) of maintenance sections with cable barrier systems in their jurisdiction keep an inventory of repair parts. Only a few maintenance sections (12 percent) keep an inventory of cables because they very rarely need replacement.

Inventory Methods

There are a number of different inventory methods being utilized throughout the state for the parts needed for cable barrier system maintenance and repair. Some of the current inventory methods are outlined in the list below:

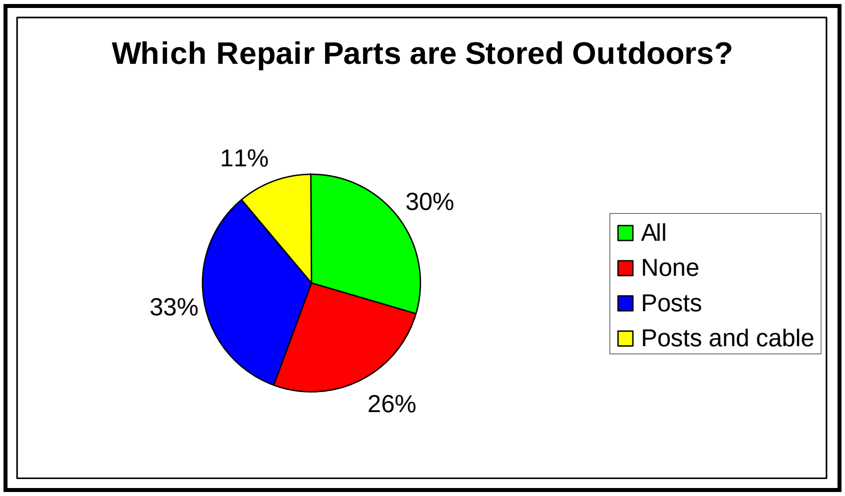
- History of impacts/frequency of repairs
- Enough parts to repair a major impact promptly
- Usually keep 75 – 100 posts, clamps, etc. in stock
- Base inventory on repair information gathered during a 90-day period
- Order parts through warehouse as they are needed
- Estimate the parts needed for a weeks repair and then keep a month’s supply on hand

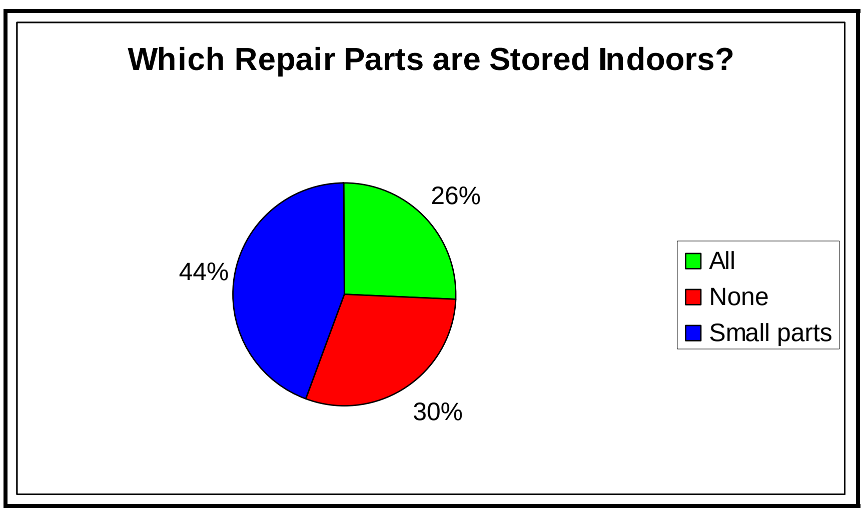
While none of the methods are necessarily superior, data suggest that major impacts to cable barrier systems can damage 20 – 30 posts and the associated hardware. In order to achieve timely repair, maintenance sections should have an adequate inventory to deal with the scenario where several major incidents occur in a relatively short amount of time. There were several maintenance sections which routinely keep an inventory of 75 – 100 line posts and the associated hardware (clamps, hooks, etc.).

Guidance – Keep an inventory of 75 – 100 posts and associated hardware to ensure timely repair of cable barrier systems.

Storage Methods

As with inventory methods, there is a wide range of storage methods being used by individual maintenance sections regarding storage of repair parts. The Weatherford maintenance section has a customized trailer that carries the inventory of repair parts for the three different cable barrier systems they currently maintain. The majority (74 percent) of maintenance sections prefer to store repair parts outdoors. The remainder (26 percent) store all repair parts indoors, with several indicating that small parts such as bolts, clamps, hooks, spacers, and turnbuckles are the only items stored indoors.





Guidance - Large repair parts (posts and cables) are appropriate for outdoor storage; whereas small parts such as clamps and hooks are appropriate for indoor storage.

Section 8

Coordination with Emergency Service Providers

There are a number of items related to cable median barrier systems that TxDOT maintenance personnel need to coordinate with emergency service responders, primarily police and fire agencies,. Some coordination with emergency responders may also be appropriate during the design phase of a cable barrier project, particularly regarding frequency and locations of emergency turnarounds. Four key maintenance-related coordination activities are

- joint training,
- vehicle removal procedures,
- cost recovery from responsible parties, and
- provision of emergency turnarounds.

Joint Training

Only a select few maintenance sections (9 percent) have conducted special training and/or informational sessions with emergency responders. Emergency responders need to be provided with sufficient information regarding cable barrier systems so that they can safely and efficiently make decisions when they are at incident scenes. In order to foster a cooperative and mutually beneficial relationship, TxDOT should make the effort to provide the relevant emergency response agencies with the information contained in the following three subsections.

Vehicle Removal Procedures

One of the most common questions that department of transportation personnel receive from emergency responders is regarding what to do when the cables become entangled with a vehicle and cannot be removed. The first instinct of emergency responders, particularly fire personnel, is to cut the cables in order to remove the entangled vehicle. Every cable barrier system manufacturer recommends similar guidance in the situation where a vehicle is entangled: cut the cables only as a last resort using extreme caution and proper procedures. A fire training website provides the following guidance for emergency service providers for cutting cable barriers:

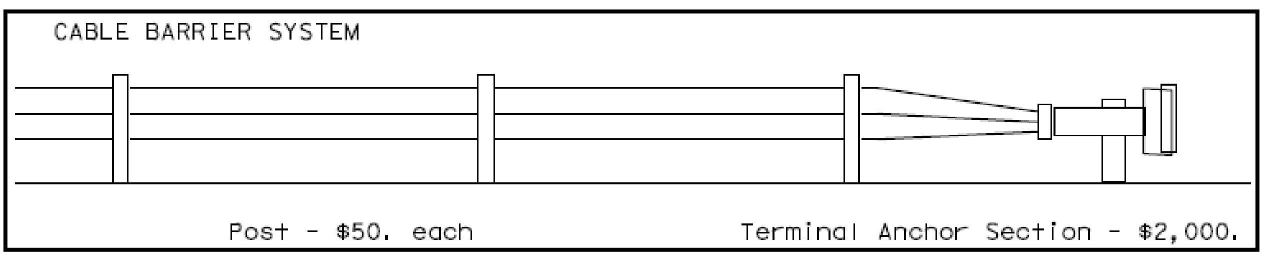
- Cutting the cables is a last resort and is only appropriate in life-threatening situations.
- If it is necessary to cut the cable(s), we recommend cutting between two (2) undamaged posts where the cables are parallel and not being subjected to multiple forces, and then cut only the minimum number of cables necessary.
- We recommend that the cable be securely taped with duct tape or other tape on each side of where it will be cut to prevent unraveling.

- ➢ If the cables are tangled around a vehicle, lifting the cables out of the post may be appropriate. However, if you start to raise the cables and the post is lifted, stop and pull the post out of the way. Use extra caution and secure the post with a chain or restraining device as it may be under significant tension if the cables are twisted around a vehicle.

Recovery of Costs from Responsible Parties

As mentioned previously in Section 3 of this chapter, efforts to identify and recover money from responsible parties that cause damage to cable barrier systems need to be more aggressively pursued. This is a difficult proposition because experience shows that many impacts to cable barrier systems are by a single vehicle that is able to drive-away from the scene before police arrive.

TxDOT should initiate coordination activities with state (Department of Public Safety) and local law enforcement agencies regarding the need for increased collaboration and emphasis on the recovery of maintenance and repair costs from impacts to cable barrier systems throughout the state. Formal policies and agreements should be considered so that the cost recovery percentage for cable barriers is increased, thereby preserving funding for other maintenance priorities. The TxDOT Traffic Operations Division currently has a publication issued in September 2007 that can be used for estimating replacement costs for traffic control devices and roadside safety devices when involved in crashes. The suggested replacement costs for cable barrier systems are $50 for each post damaged and $2,000 if a terminal anchor section is damaged.



Guidance - Utilize the replacement costs developed by the TxDOT Traffic Operations Division for recovery from responsible parties.

Provision of Emergency Turnarounds

Planned cross-over locations should be coordinated with local emergency responders. Some emergency responders initially reacted negatively to the placement of barriers in medians with limited cross-over access. However, as experience was gained and the number of serious incidents reduced, emergency responders are mostly supporters of median barrier installations. The maximum distance between access points typically varies between one to five miles.

Research has shown that states are using different methods for handling crossovers. Some states allow a gap for crossovers by terminating and restarting the cable barrier. Some other states use a staggering technique, in which the ends of two cable barrier installations are installed at a lateral offset from each other. This technique minimizes the window through which an errant vehicle can crossover the median at design speed and encroachment angle. Overlapping the ends of two cable barrier installations was another technique employed by some of the states. In this method some lateral gap is left between the overlapping ends of the two installations. The gap can be used by patrol or emergency vehicles to crossover after making an S-turn. Some states indicated switching sides of the median at a crossover location in addition to staggering and/or overlapping the barriers.

Section 9

Mowing Operations

One of the greatest areas of concern with cable barrier systems from a maintenance perspective is with the management of vegetation in and around the barrier. Cable barrier systems must have delineation at 100 foot spacing unless otherwise approved by the project engineer. This delineation is important, particularly at night, so that motorists can readily see the cable barrier system and avoid "nuisance" impacts. Roadside vegetation (e.g., grasses and weeds) can grow to sufficient heights to obscure the presence of the cable barrier systems, causing safety concerns. It is important to understand that mowing and herbicide operations are life-of-the-facility cost considerations.

Guidance – Mowing and herbicide operations are life-of-the facility cost considerations and this supports the need for mow strip installation with cable barrier systems.

With Mow Strip

Concerns regarding management and control of vegetation around cable barrier systems can be largely addressed with the addition of a mow strip. The use of mow strips for vegetative management purposes has gained wide acceptance in Texas. The Maintenance Division encourages the use of mow strips to reduce future hand mowing or herbicide operations. A secondary benefit is that a reinforced mow strip will also provide additional resistance to movement of socket foundations. Distance between the edge of a travel lane and cable barrier should consider mower widths. The same consideration applies to distances between cable barrier and other objects such as guardrail, bridge columns, and end treatments.

> **<u>Guidance</u> –** Distance between the edge of travel lane and cable barrier should provide adequate space for mowing operations. The same consideration applies to distances between cable barriers and other objects such as guardrails, bridge columns, and end treatments.

Some maintenance personnel have indicated that there are issues even with the addition of a mow strip. Some concerns include:

- inadequate widths for large mowers,
- complicating other maintenance activities such as pothole repair on inside shoulders, and

- mow strips that are too narrow so that mowers have trouble staying away from the posts.

Without Mow Strip

Cable barrier systems installed without a mow strip complicate the vegetation management process. One of the biggest drawbacks is the significantly increased need for hand trimming, which is a costly maintenance item in both time and money. Some states have utilized products such as weed mats in lieu of asphalt or concrete mow strips to control vegetation growth.

Section 10

Performance Evaluation

The evaluation of performance of maintenance practices and roadside safety devices is extremely important. Roadside safety devices such as high-tension cable barrier systems are a relatively new application in Texas dating back to the middle of 2003. As experience with cable barrier systems grows, TxDOT personnel will be able to improve the engineering and maintenance aspects. TxDOT maintenance personnel should commit to monitoring key performance aspects of cable barrier systems, including:

- barrier impact frequencies,
- repair costs,
- recovery of costs from responsible parties, and
- barrier failure events.

> **<u>Guidance</u> –** TxDOT maintenance personnel should commit to monitoring key performance aspect of cable barrier systems so that in-service performance can be evaluated.

Barrier Failure Events

One of the most important activities for the performance evaluation is collecting detailed information when the cable barrier system fails to prevent a crossover crash. Common types of failures for cable barrier systems include over-ride and under-ride. Surveys of maintenance personnel revealed that there have been several cable barrier failure events, with both passenger vehicles and large trucks crossing into the opposing travel lanes. When available, TxDOT should obtain a copy of the official police crash report for barrier failure events. The following provides a comprehensive list of key information that is valuable in the evaluation of cable barrier failure events:

- official police crash report;
- any available photographs of barrier in section of impact and involved vehicle(s);
  - impact angle,
  - site conditions, and

- documentation of any contributing factors (e.g., vehicle was rolling prior to hitting barrier, improper barrier installation, etc.) that are relevant to why the cable barrier did not contain the vehicle from crossing into the opposing travel lanes;

The information on barrier failure events should be submitted to the design division for centralized analysis, so that any patterns and corresponding corrective actions can be identified.

Guidance – Information on cable barrier system failure events should be submitted to the TxDOT Design Division for centralized analysis.

Appendix

Standard Forms

MAINTENANCE / REPAIR LOG
Wire Cable Median Barrier Systems

ACCIDENT INFORMATION

DATE: ____________ ***LIGHT CONDITION:*** DAY NIGHT UNKNOWN

TIME: ____________ ***ROAD CONDITION:*** DRY WET ICY UNKNOWN

HIGHWAY: ____________ ***APPROX. REFERENCE MARKER:*** ____________

DIRECTION OF TRAVEL: NORTH SOUTH EAST WEST

VEHICLE TYPE: CAR TRUCK SEMI UNKNOWN

PROPERTY DAMAGE ONLY: YES NO ***NUMBER OF INJURIES:*** ____________

(No Injuries/Fatalities) ***NUMBER OF FATALITIES:*** ____________

PREVENT CROSSOVER: YES NO

BRIEF DESCRIPTION OF INCIDENT:

REPAIR INFORMATION

DATE: ____________

TIME: ____________

PRODUCT: BRIFEN TRINITY GIBRALTAR NUCOR/GSI ***# OF EMPLOYEES:*** ____________

 # OF HOURS: ____________

 # OF POSTS REPLACED: ____________ ***MATERIAL COST:*** ____________

LABOR COST: ____________

END TREATMENT INVOLVED: YES NO

BARRIER FAILURE LOG
Wire Cable Median Barrier Systems

FAILURE INFORMATION				
DATE:	______________			
TIME:	______________			
ROADWAY:	______________			
DISTRICT:	______________			
MAINTENANCE SECTION:	______________			
PRODUCT:	BRIFEN	TRINITY	GIBRALTAR	NUCOR/GSI
DPS CRASH REPORT #:	______________			
FAILURE TYPE:	UNDER-RIDE	OVER-RIDE	PENETRATION	OTHER

PHOTO	***DESCRIPTION***
1	
2	
3	
4	
5	

DESCRIPTION OF CONTRIBUTING FACTORS OF FAILURE OF BARRIER SYSTEM TO CONTAIN VEHICLE(S) FROM CROSSING INTO OPPOSING TRAVEL LANES: